Universal Design for Learning and Diversity in Elementary School: Experience Report

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Abstract. As the Information Technologies and Communication (ITCs) are to be seen as an important resource in classrooms at all levels of learning, it is necessary to think about how to ensure that these ITCs meet the needs of diverse learners. In this article, we are introduced to the Universal Design for Learning (UDL), which was used to develop and to refine a digital didactic material based on a printed book used in more than 100 Brazilian schools. A case study was conducted in a classroom of the first grade of elementary school to verify the benefits and the difficulties in implementing such an approach. The results of this experiment are presented in this article.

Keywords: Universal Design for Learning, Diversity, Digital Inclusion, Accessibility, Digital Didactic Material.

1 Introduction

According to UNESCO, about 10% of the population, or 650 million people, have a disability. They are the largest minority in the world. Thus, there are millions of people around the world who face significant barriers in the educational, health, employment and social services sectors, including housing and transport [1]. In the Brazilian scene, according to the last census (2010), 45 million people had at least one type of disability [2]. In developing countries, 90% of disabled children do not attend school [3].

Following the agreement on the Rights of Persons with Disabilities, adopted by the United Nations in 2006, some actions were instituted by the Brazilian government, among which is the Brazilian Law on Inclusion for the Disabled [4]. This law requires schools to accommodate students with disabilities in mainstream education and to adopt the necessary adaptation measures and any financial burden could be transferred on to rates. A major problem to be solved is that the didactic material has

not been developed taking into account the specificities of these students so that they are not prepared to them [1].

Differentiation is a process that seeks to address the teaching-learning process taking into account the different abilities of students in the same classroom. The purpose of it is to maximize the growth of each student from the knowledge of the student's profile and the ability of the teacher to respond to this variation. The different skills among students may be the result of a number of factors, such as students with diagnosed learning difficulty (e.g. dyslexia), students with disorders like spectrum autism (ASD) or attention deficit hyperactivity (ADHD), students who need to adapt to cultural and linguistic differences of the countries they came from, high ability students or even those who do not find enough support at home [5].

It is essential that diversity is respected by the improvement and the enhancement of each student's skills. It is necessary to discuss the use of computer resources in this process, how people can benefit from the use of different possibilities of access to information, reaching knowledge.

Therefore, the effectiveness of projects and educational products requires the involvement of professionals from the technological and educational areas. At the first, it is expected that they should know the strategies to offer flexible and widely usable solutions, promoting the autonomy of the people in their diversity in carrying out their daily activities. For education professionals, it is important to know these technological solutions in order to promote the skills of these students [6] [1].

In this context, the use of Universal Design for Learning (UDL) and Web Accessibility principles [7] were investigated aiming at the construction of accessible digital materials and dedicated to the prism of diversity. The main purpose was to verify that such material would be able to serve students in the classroom, regardless of their needs, disabilities, preferences and learning profile. Therefore, an accessible digital material based in a printed educational book used for the kids' literacy of Elementary I was developed, using the UDL. Then, this digital material was applied to a class of the first year of elementary school.

2 Universal Design for Learning

UDL is a concept coined by [8] resulting from an interventional proposal originated from the architecture, the Universal Design [9]. For Mace, tools and environments should be built in order to be useful and usable by everybody, without distinction, regardless of age, abilities and anthropometric, sensory or motor impairments (chronic or temporary). In this sense, both the Universal Design as the Universal Design for Learning is underlying in seven principles: 1)Equitable use design, that is, useful for diversity; 2) Use Flexibility, in which the design must accommodate individual abilities and preferences; 3) Simple and intuitive use design, which is independent of experience, prior knowledge or cognitive skills; 4) Design to communicate its information both purpose and usability of undoubted manner, regardless of the environment or the user skills; 5) Design with tolerance of error, minimizing aversive consequences of unintended actions; 6) Design that requests low

physical effort for its efficient use; 7) Size and space to facilitate the handling of the product without the concern on size, posture or mobility of the user [10].

It can be seen that there are three major areas of concern throughout the development of the principles, which are: Flexibility of use for diversity (1 and 2), Intellective Accessibility (3, 4 and 5) and Motor Accessibility (6 and 7). This is because realizing these areas, diversity might be considered more effectively without - necessarily - thinking of ultra-personalized methods, taking into consideration only the necessary customization required for accessibility of sensory and motor afferents that are possible to each user.

In educational terms, these principles apply to the preparation of a curriculum that gives learning opportunities and highlights the skills of learners. An apparatus that causes challenges as much as guarantees the support idea, leading genuinely the students' development. In this context, we face the problem of the current Educational Paradigm, which cares more about behaving like a diffusing education of information than knowledge makers.

Advances in neuroscience researches clarify, however, that for the sedimentation of learning, there are three major neural networks that facilitate the process of acquiring knowledge and not just the recognition. They are "Care and Prioritization", "Recognition", "Action and Expression" networks

The "Care and Prioritization" network, also called "Why?" course of learning, is responsible for the engagement in knowledge from stimuli that evoke motivations of each learner, which concerns the affective dimensions of learning. To this end, the island and the limbic areas are convened.

The "Recognition" network, also called "What?" course of learning, is responsible for the representation of activity, i.e., for the construction of a symbol that identifies the object to be known. It integrates the temporal, occipital and parietal areas of the brain (brain sensory areas) in order to design such representation. For this reason, it is essential that different ways of presentation of the object to be studied are presented.

The "Action and Expression" network, also called "How?" course of learning, is responsible for the sedimentation of knowledge based on strategies and student's particular skills to express the acquired knowledge. In this context, it brings together the front and medial areas of the brain.

3 Related Work

Some works related to this research were found in the literature. One of the first initiatives to make use of the UDL was developed by [11]. According to [12], the project to develop a digital book has been guided by three principles: to create a flexible digital version of a didactic book containing all the information found in the original; to build the access bases and the learning strategies; to develop activity models that would make pleasing to the students in using the digital environment for learning.

[13] proposes a digital educational book accessible to the visually impaired. In this work, the printed version of the book is adapted using new features such as hyperlinks, multimedia content, exercises, educational games, among other resources. The proposed digital book has three main parts: a screen reader to read the whole text

portion; a tool to perceptions of figures that works providing tactile and audio feedback in touchscreen devices; a streamlined interface that allows visually impaired people to draw using their fingers. The main point to allow the user to draw is to provide immediate feedback while he is interacting with the book.

[14] also present an experience report on the development of an accessible material in the context of the classroom in a discipline of Human-Computer Interaction in undergraduate courses in Computer Science Area. These students have developed a learning support material, aimed at children of Elementary school, based on the UDL concept, considering the skills of every student, regardless of his physical or cognitive impairments. This experience has shown the engagement and involvement of students in the search for solutions in the development of the above-mentioned material that meets the different needs of the target audience.

[5] bring the results of their studies about as Computer Science, going from an extension activity for a normal activity of elementary school classroom, must have its curriculum examined to ensure it is meeting the needs of students with different skills. Thus, they present as the Universal Design for Learning was used to develop and to refine a programming environment and the curriculum for 9 to 12-year-old students (elementary education).

In this work, it was used a textbook in print format widely used in the Brazilian educational system to develop and to refine a digital didactic material. Part of this printed book was adapted for the Web version and characteristics were inserted to become it, besides accessible also more interactive. For example, the student could have immediate feedback on activities and interactive exercises in order to streamline the teaching-learning process.

4   Accessible Digital Material

This project lasted about four months and involved two graduate students in Computer Science, a student in the Post- Graduate Program in Developmental Disorders, also pedagogue, and two teachers from the same graduate program. It occurred among the months of October 2018 and January 2019.

The study was approved by the Ethics Committee of the Mackenzie Presbyterian University, approval protocol number: 3.097.742 and all ethical principles have been met.

To develop this work, the first chapter of a printed textbook, used to children literacy of elementary school I was adapted for an accessible digital material. This digital material should follow UDL principles and Web accessibility.

As regard to content, the printed book is composed of four main parts: Portuguese Language (composed of activities focused on the presentation of the alphabet and association between sound and letter); Mathematics (association between numbers and quantities); Sciences (living, non-living and environment concepts); Geography (day and night concepts and the elements that can be seen in the sky on each occasion).

Traditional programming resources for web development were used aiming at developing accessible digital material. The site consists of HTML 5, CSS 3 and JavaScript 1.8.5. All source code has been written using the Sublime 3.2 text editor

and for versioning and hosting the chosen platform was GitHub. The audio was generated using the API ResponsiveVoice 1.5.

The accessible digital material was adapted seeking to keep the paging standard and the content as faithful as possible to the original. The resources implemented in this material were:

- Repertoire expansion: Two videos were added, that is, there were two links in which the students, when they click, had access to videos that expanded the knowledge and provided additional information on the subject. Some terms also could be clicked and brought only additional information (text and images) on the subject.
- Students' expressions: Students were encouraged to do the activities on the tablet; however, some activities have been adapted and modified in their form of interaction. For example, there was an activity in the printed book the student should paint the creatures that were in the illustration. In the digital book, the student should have to click on living creatures that were removed from the illustration and presented individually. The student could carry out the activity in the traditional media (book) or in the digital environment (Fig. 1).
- Information Production in different media: audio description and videos. The pedagogue created a descriptive text for all images. Thus, the screen reader accesses to this text, which can also be activated via a button for audio, inserted near the picture.
- Subject summary: At the end of each subject was added a summary in order to expand the knowledge.
- Support tools: For all content writing (explanations, statements and alternative text) of the material there is a button for reading aloud; a virtual keyboard that is a simplification of a regular keyboard and there is also the possibility of access to a calculator and a number line to assist in the calculations.

4.1 Multiple ways for presentation (UDL - Recognition)

To provide multiple means for presentation, the digital availability of explanatory written texts on the subject was used, as well as videos, animations, music, images, audio, texts audio description, different levels of information deepening, links inclusion containing explanatory videos and games as opposed to what existed in the printed book (text and images). Additional text (glossary) was also aggregated so that the student would know more about a subject. Fig. 1 shows this feature applied to the word ENVIRONMENT.

Through this Fig. 1, see several other features implemented on digital material can be seen:

- Speaker icons next to the texts: the student can click and listen to the corresponding audio to text.
- Speaker icons on the images: the student can hear the audio description of the image.
- "Aa" Icon: the student can increase or decrease the text font.

- Keyboard icon: the student can trigger a virtual keyboard that has only the letter keys and numbers.
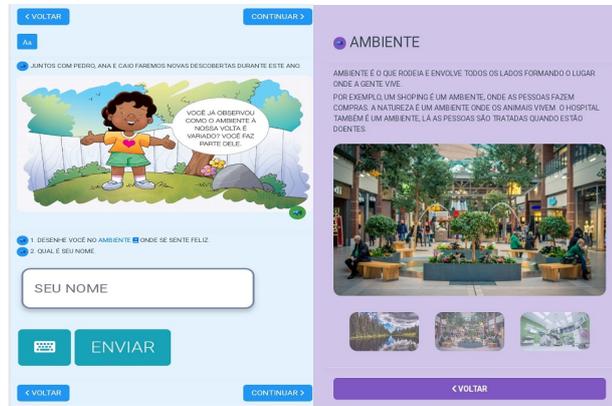
Fig. 1. Use of various resources for information presentation

4.2 Multiple ways for Action (from UDL - Action and Expression)

By multiple ways for action is understood the availability in the digital didactic unit of various possibilities for carrying out the activities. For example, in math activities, the student could solve them using the mental calculation, algorithms, calculator, number line, count term by term, design, oral answer and record in the book. In Fig. 2, two features are shown: the calculator and the number line (circled in red elements).

Fig. 2. Additional tools for promoting learning

In addition, in the digital material, the image has been modified, cutting from the scene, only the fish, allowing students to focus their attention only on the object of study (fish count).

4.3 Multiple ways for Engagement (from UDL - Care and Prioritization)

Multiple ways for engagement relate to the range of situations in which students can perform them alone, in groups, in pairs, with the help of a more experienced colleague or with the teacher. Besides, it has been proposed challenges with varying difficulty levels to sustain the motivation of all students as well as the immediate validation of the student's answers in order to allow their self-regulate and to manage the time according to their demands, as illustrated in Fig. 3.

The purpose of additional features usage such as text audios, audio description, number line, calculator, virtual keyboard, tips, increase or decrease of the text font was to provide greater autonomy to the student, which could hold some activities even whether he was not yet fully literate.

In addition, all activities of the digital material involving "to click" can be performed with or without the mouse, as all fields are accessible via keyboard. For pedagogical reasons, the student is not penalized when mistaken an activity. He can try as many times as he wishes until he finds the correct answer.

Fig. 3. Immediate feedback activities

5 Application of Accessible Digital Material

After the implementation of digital material, the application of the material in the first year of an elementary schoolroom of a private school in the city of São Paulo, Brazil, was held. All students enrolled in the afternoon period also the teacher of the room was included in the study. Altogether, there were seven students in this first year, five boys and two girls. Among boys, three were five years old and two boys were six. A girl was five years old and the other was six.

Data collection began with a pre-test (18 questions in all, about a subject related to the digital material content), performed by all participants in order to assess their prior knowledge. After this time, there was the use of individual tablets, with the digital material available for handling. Data were collected by recording the tablets screens. After the intervention, a post-test (18 questions, about subject related to the digital material content) was applied to assess whether there was an improvement in student performance. The teacher answered a specific questionnaire to evaluate the digital material. In the last stage of the study, data were analyzed and described. The study with the students took place in four days in the same week during the class-time. The

classroom teacher was present during all data collection and she assisted the research in helping the students whenever it was necessary.

6   Results and Discussion

According to the response of the students of the post-test questionnaire administered on the last day of the survey, the students considered the digital teaching material a feature that kept them engaged and motivated during the execution of activities. They gave preference to the digital version compared to print. They assessed that the digital teaching unit facilitated learning and highlighted "TIP" as the most important educational resource in the reduction of learning barriers. The audio was the accessibility feature that students excelled as a facilitator of learning.

Regarding the perception of the classroom teacher, she has assessed the digital didactic resource as one that facilitated student learning, as met the individual needs of students, allowing them to do activities at their own pace and independently. She pointed out that there is a lack of accessible teaching materials in schools. The audio was appointed by the teacher as the resource that decreased learning barriers and promoted the autonomy of the students so that they were able to carry out the activities themselves without the intervention of the teacher.

According to the results of the comparison between the pre-test and post-test, it was noted that this group of students had an effective learning moment. These data relating to 10 multiple choice questions, the result showed that there was an improvement in five of them, averaging 37.128%; three questions had no improvement and a question had worsening of 42.84%.

7   Conclusions

This research aimed to highlight the importance of developing accessible digital didactic materials as a way to minimize the learning barriers that hinder access to the school curriculum. From UDL assumptions, an accessible digital material based on a chapter of a physical book was drawn up. It was not in the scope of this research to test the material, specifically with students with disabilities, but in a classroom, regardless of the kind of student found. In relation to the conclusions presented by analyzing the collected data, it can be seen that:

- From UDL guidelines that have been identified and used in the digital material, prepared in this research, the audio was the most used resource by the students and a facilitator of learning. The first-year students, for not being fluent readers, were benefited from reading the texts and activities. Audio promoted the autonomy and independence of the students, as they needed less of the teacher's mediation. A positive relationship between the use of audio and the rightness in the activities was established.
- Provide additional explanations through features such as links to external videos, tips and use of contextualized images, decreased learning barriers and facilitated access to the content, since the student could immediately

clarify his doubt, triggering one of the resources. However, it was observed that over these resources (two similar videos) made the students distracted. There is a need to assess the number of resources and strategic use to minimize unwanted side effects.

- The immediate validation of responses increased students' motivation, involvement in the task and autonomy, allowing them to self-regulate and to manage the time according to their demands.
- The digital material should also work in offline mode so that there are no problems related to the use of the internet.
- Student responses should be recorded for both the teacher to have access to them, following the development of the student and proposing actions to remedy possible problems and for the student to have the record of his schooling path.

It can be concluded that digital didactic material based on UDL guidelines, was an easy handling tool for the student, of intuitive use, in other words, the student himself triggering the various features and experimenting them was able to understand its operation. It promoted autonomy, independence, motivation and time management by the student.

The digital didactic materials were a tool that considered the diversity of students, offering varied ways of presenting the content, reducing thus the learning barriers. For example, lack of care with low contrast figures or information overload can cause misunderstanding by any type of student (typical or disabled), making the learning process more difficult. This research has shown that when it is offered other ways of content presentation, students were able to learn.

Creating digital didactic materials based on the UDL guidelines is a possibility to decrease the learning barriers and to facilitate access to the curriculum since it is still a national education challenge.

Acknowledges

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